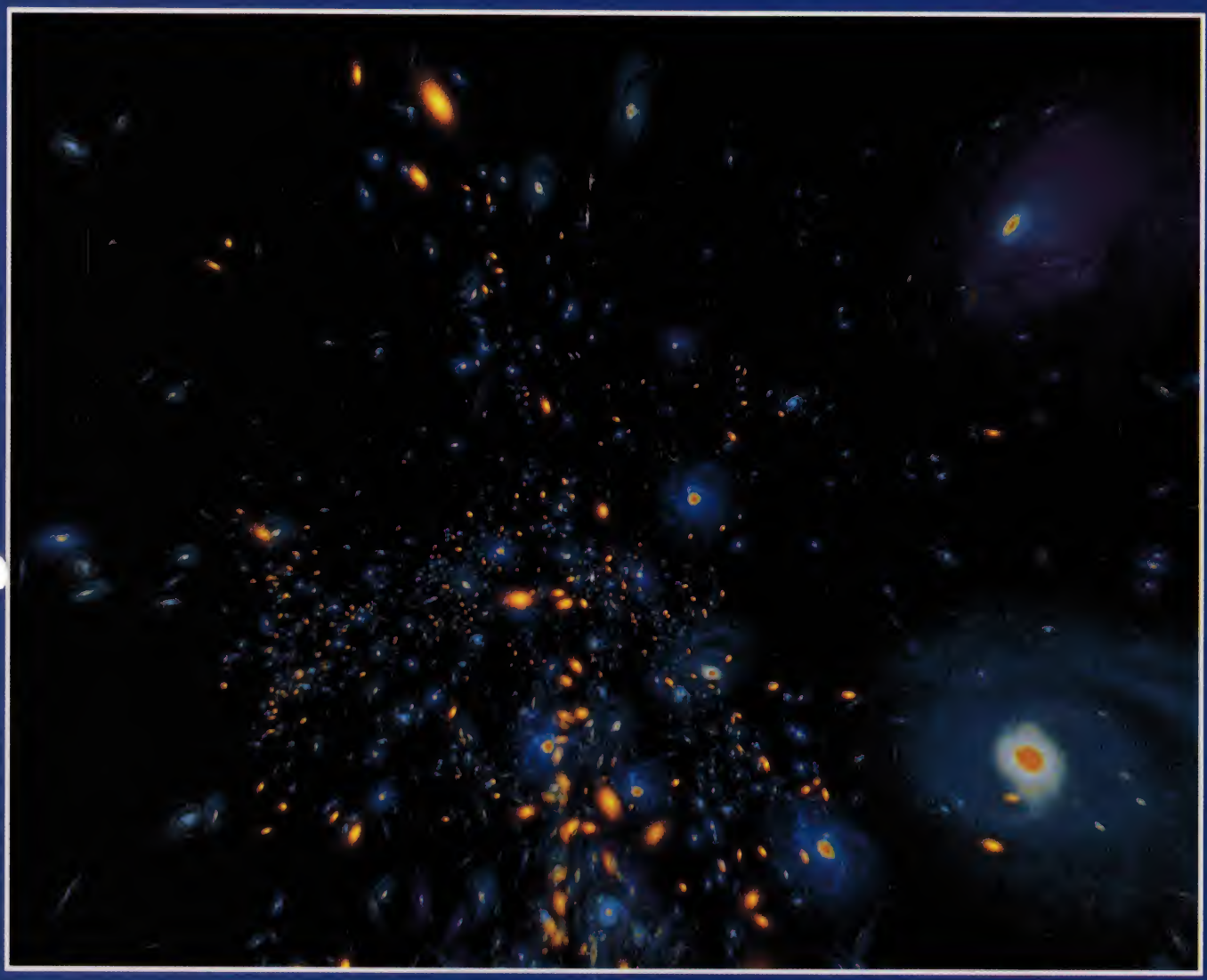
The Weekly Newsmagazine of Science

SCIENCE NEWS

May 1, 1993
Vol. 143, No. 18
Pages 273-288



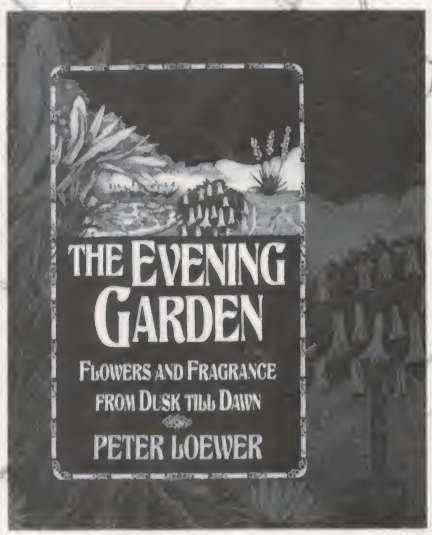
Grand-Challenge Computing

To order by phone from Science News Books, call:
1-800-544-4565
(Visa or MasterCard Only)
In D.C. Area:
202-331-9653

Macmillan, 1993, 256 pages, 7½" x 9½", hardcover, $25.00

For the many people who work and only have time to care for and enjoy their gardens after the daylight hours, *The Evening Garden* is a celebration of the hundreds of plants that bloom and/or release their fragrance after the sun goes down. Orchids, cacti, annuals, perennials, vines, water lilies, wildflowers, and trees are all included. The entry for each night bloomer contains a detailed description and tips on cultivation, along with its range of hardiness. There's even a list of 99 varieties of daylily that open or stay open late into the evening hours, contrary to the name.

In addition to a chapter on creating the classic "moonlight" garden, complete with an extensive sample plan and a list of more than 75 white-blooming annuals, perennials, bulbs, shrubs, and trees, there are chapters on the night sky and on the creatures that light it and fill it with movement and song — fireflies, glowworms, moths, bats, owls, tree frogs among them.



Packed with more than a hundred beautiful line drawings, *The Evening Garden* is an evocative and highly informative book that will help you create a garden of wonder and delight that you can enjoy from sundown into the evening darkness.

— from Macmillan

Science News Books, EveningGardH
1719 Street, NW,
Washington, DC 20036

Please send me _____ copy(ies) of *The Evening Garden*. I include a check payable to Science News Books for $25.00 plus $2.00 postage and handling (total $27.00) for each copy. Domestic orders only.

Name _____

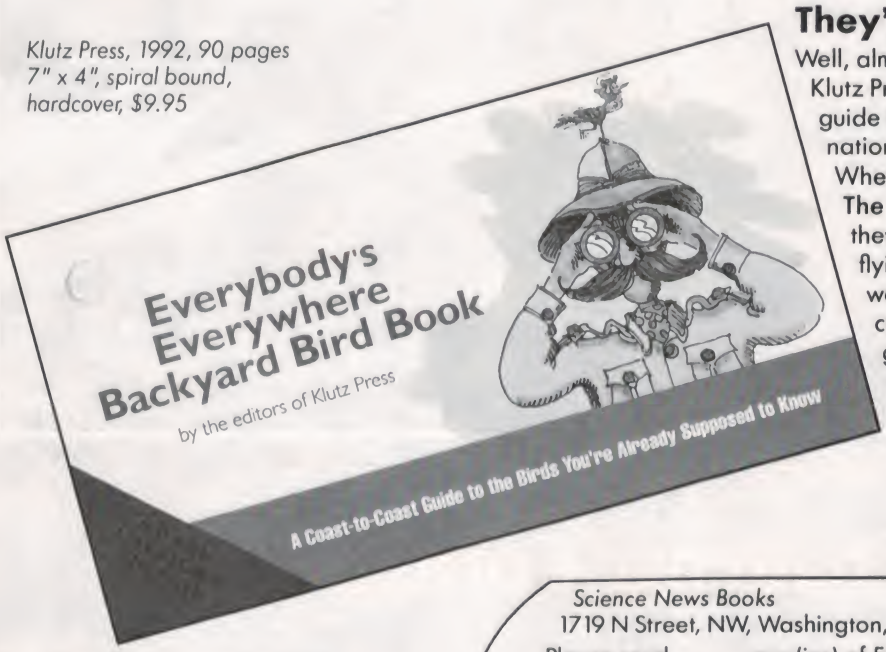
Address _____

City _____

State _____ Zip _____

Daytime Phone _____
(used only for problems with order) RB1821

Klutz Press, 1992, 90 pages
7" x 4", spiral bound,
hardcover, $9.95



They're Everywhere!

Well, almost everywhere.

Klutz Press has prepared a unique beginner's guide to 26 very special birds, winners of our nationwide "Most Likely to Be Seen No Matter Where You Live" contest. We've named them **The All-Continent All-Stars** and even though they're so common one of them is probably flying directly over your head right now, we've profiled each of them with a collection of interesting tidbits and general birdwatching hints that should enable you to (finally!) identify each and every one of them. *— from Klutz Press*

Packaged with the guide is the Audubon Birdcall, the most popular birdcall ever manufactured. Recommended for ages 8 and up.

To Order by Phone, Call:
1-800-544-4565
(VISA or MasterCard Only)
In D.C. Area: (202) 331-9653

Science News Books BkydBirdBook
1719 N Street, NW, Washington, DC 20036

Please send _____ copy(ies) of *Everybody's Everywhere Backyard Bird Book*. I include a check payable to Science News Books for $9.95 plus $2.00 postage and handling (total $11.95) for each copy. Domestic orders only.

Name _____

Address _____

City _____ State _____ Zip _____

Daytime Phone _____
(used only for problems with order) RB1822

SCIENCE NEWS®

The Weekly Newsmagazine of Science

cience Service Publication
Volume 143, No. 18, May 1, 1993

This Week

Research Notes

Articles

Departments

SCIENCE NEWS (ISSN 0036-8423) is published weekly on Saturday, except the last week in December, for $39.50 for 1 year or $68.00 for 2 years (foreign postage $6.00 additional per year) by Science Service, Inc., 1719 N Street, N.W., Washington, DC 20036. Second-class postage paid at Washington, DC, and additional mailing office. POSTMASTER: Send address changes to SCIENCE NEWS, P.O. Box 1925, Marion, OH 43305. Change of address: Four to six weeks' notice is required — old and new addresses, including zip codes, must be provided.

Editorial and Business Offices:
1719 N St., N.W., Washington, DC 20036
(202-785-2255)

Subscription Department:
P.O. Box 1925, Marion, OH 43305
For new subscriptions only, call 1-800-247-2160.
For customer service, call 1-800-347-6969.

Science Service, which publishes SCIENCE NEWS, is a nonprofit corporation founded in 1921. It gratefully accepts tax-deductible contributions and bequests to assist its efforts to increase the public understanding of science, with special emphasis on young people. More recently, it has included in its mission increasing scientific literacy among members of underrepresented groups. Through its Youth Programs it administers the International Science and Engineering Fair, the Science Talent Search for the Westinghouse Science Scholarships, and publishes and distributes the *Directory of Student Science Training Programs for Precollege Students.*

Letters

Flying to conclusions?

To point out that the foot of *Archaeopteryx* resembles that of the perching bowerbird more than that of the predominantly ground-dwelling lyrebird ("Flight: A bird hand is worthy in the bush," SN: 2/6/93, p.87) is to overlook three things: that the foot of *Archaeopteryx* resembles neither very closely; that it is very similar indeed to the feet of small theropod dinosaurs whose fossils are of the same age as that of *Archaeopteryx;* and that there are 140 million years of evolutionary change behind every modern bird.

Dennis Hibbert
Seattle, Wash.

Charm of the versatile bacterium

The versatile bacterium *Shewanella putrefaciens* was first characterized by a colleague of mine, Charles R. Myers, one of the U.S. researchers involved in studying the Black Sea in 1988 ("Minding those microbial mineral-makers," SN: 2/13/93, p.110). His original work required some interesting innovations in the methodology for both growing the bacteria and detecting the metal reduction process.

This particular bacterium is capable of manganese reduction in a most unusual way: It actually works with manganese in its solid form and uses this reaction to provide energy for its life processes. This would be much like a minute speck of dust actually performing a chemical modification of your computer screen!

Part of the charm of this organism is that the enzymes which perform the reduction — unlike those of any other bacteria known at this time — are found in the outer membrane! In addition, it is possible that the lessons learned about reduction processes from many of these microbes can be beneficial in terms of human health. This is because reductive metabolism is at the root of a number of pathological conditions. These microbial mineral-makers are indeed versatile and interesting.

Mary L. Haasch
Research Assistant Professor
Medical College of Wisconsin
Milwaukee, Wis.

Lower figure, less accuracy?

In "Depressing news for low-cholesterol men" (SN: 1/16/93, p.37), it is stated that "Among men age 70 and older, nine of 75 in the low-cholesterol group — about 16 percent — reported symptoms of mild to severe depression." A complex calculation indicates 12 percent. This lower figure may affect the statistical accuracy of the conclusions reached — that is, that low cholesterol may be related to depression in older men.

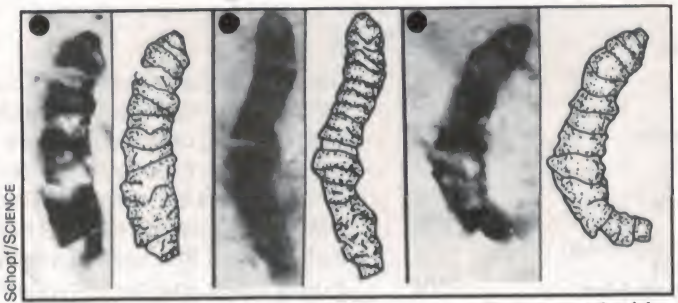
H. H. Denman
Professor of Physics
Wayne State University
Detroit, Mich.

Fossils Show Early Diversity of Life

The record of ancient life preserved in Earth's oldest rocks shrinks to a handful of tattered pages as paleontologists struggle back through time to the Archean era — the first 2 billion years of our planet's history. Now, recently identified fossil microorganisms add a potentially important chapter to that incomplete record. These fossils suggest that a diverse range of cyanobacteria — creatures that use light as an energy source and produce oxygen — may have thrived about 1 billion years after Earth formed.

Paleobiologist J. William Schopf of the University of California, Los Angeles, has identified 11 distinct species of cyanobacteria-like creatures preserved in 3.465-billion-year-old rock deposits in western Australia. The microscopic creatures, embedded in some sort of sticky substance, probably lived in shallow water, says Schopf. They grew into filaments of connected cells, resembling the cyanobacteria discovered previously in 2.1-billion-year-old Canadian rocks, Schopf reports in the April 30 SCIENCE.

The microorganisms vary significantly in the shapes of their individual cells and in their overall lengths and thicknesses. This diversity demonstrates that primitive life had already seen great evolutionary change by an early point in Earth's history, says Schopf.



Schopf/SCIENCE

Images and matching interpretive drawings of three individual microorganisms from a collection of 3.5-billion-year-old fossils discovered in western Australia.

Considering the odds against the preservation of such ancient fossils, Schopf comments, "I feel just enormously pleased that we've finally got something that's nearly 3.5 billion years old, that's diverse and interesting and well-preserved enough to interpret." Over time, heat and pressure can all but obliterate traces of ancient life from the geological record.

But are Schopf's fossils truly the ancestors of oxygen-making cyanobacteria? Currently, the identity of these somewhat poorly preserved microorganisms remains subject to interpretation. "I personally think it will turn out that these are cyanobacteria, but it's very difficult to nail that at the moment," says Schopf.

The true identity of the creatures in Schopf's fossil menagerie may bear on a controversial question: When did Earth's atmosphere begin to build up significant concentrations of oxygen? Proof of a thriving population of oxygen-generating cyanobacteria 3.5 billion years ago, Schopf maintains, "would show that the current ecological system, with oxygen production and utilization . . . may well have been established at a remote time in Earth's history."

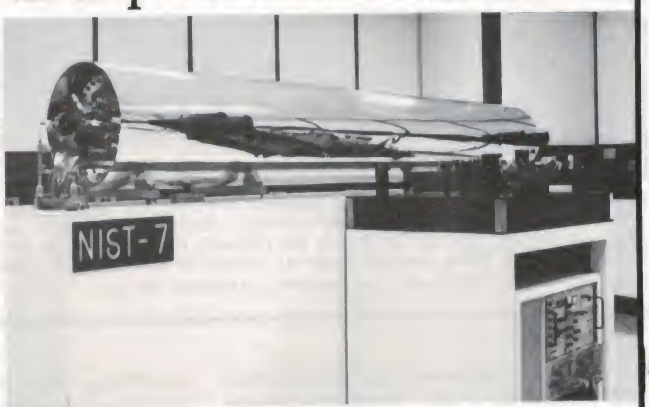
Scientists who accept the conventional wisdom on the "rise of oxygen" might disagree with Schopf. Until about 2.. billion years ago, according to the standard account, dissolved iron in the oceans combined with any free oxygen in the environment. Thus, aerobic (oxygen-using) creatures — phytoplankton, for instance — could not have existed in the Archean era described in textbooks.

In contrast to this standard view, accumulating evidence indicates that oxygen-producing microbes evolved early in the Archean era and began to enrich the oceans with oxygen, argues Kenneth M. Towe, a paleobiologist at the Smithsonian Institution in Washington, D.C. Towe's research suggests that the amount of iron present in the Archean oceans could not have soaked up all the available oxygen (SN: 12/1/90, p.347). Without aerobic organisms around, atmospheric oxygen would surely have built up earlier than many believe, he says.

The mystery of when Earth's oxygen levels rose is so complex that proving cyanobacteria existed 3.5 billion years ago will not in itself settle the issue, says paleontologist Andrew H. Knoll of Harvard University. "Dealing with almost anything in the first half of Earth's history is not simple, because the rock record stinks," he explains. However, "some glorious insights have been generated, and think that just the ability to say life was present 3.5 billion years ago is really great."

— D. Pendick

Starting up an improved atomic clock



NIST

It doesn't look at all like the trusty digital alarm clock you may have at your bedside, but it certainly keeps better time. Placed into operation on April 22 by the National Institute of Standards and Technology (NIST) in Boulder, Colo., this new atomic clock will neither gain nor lose a second in the next 1 million years. Designated NIST-7, it replaces NBS-6, the atomic clock started up in 1975 to serve as the U.S. contribution to setting and maintaining the international standard for time and frequency.

The clock's glistening, cylindrical facade, about 2.2 meters long, hides several layers of magnetic shielding. Within this cocoon, a small oven at one end gently heats up cesium metal to release cesium atoms, which are collimated into a narrow beam only 1 millimeter wide. As the cesium beam passes down the center of a long, evacuated tube, laser light excites the individual atoms to ensure that they all end up in the same electronic state.

These atoms then enter a 1.55-meter-long chamber in which microwaves reflect back and forth. The frequency of these microwaves — 9,192,631,770 hertz — corresponds precisely to the energy needed to excite a cesium atom from its initial electronic state to a state of slightly higher energy. Bathed by another laser, the microwave-excited atoms then fluoresce, giving off electromagnetic radiation. Electronic circuitry locks the microwave signal to this atomic signal, so the system maintains a constant frequency. One second is represented by 9,192,631,770 of these vibrations.

"It's actually a fairly simple procedure," says NIST's John P. Lowe. But it took years of effort to refine the technique and build a better clock.

Housecleaning cells may become assassins

Four years ago, scientists reported that in rats, large doses of vitamin A transform minimally toxic doses of carbon tetrachloride into a potent liver poison. Because the vitamin by itself exhibited no adverse liver effects, the researchers began investigating to find the agent behind vitamin A's lethal action.

Last week, they unmasked the villain. And in classic murder-mystery fashion, they show that Kupffer – the "butler" – did it.

Named for 19th century anatomist Karl W. von Kupffer, these liver residents form an integral part of the immune system. Like other macrophages, Kupffer cells remove unwanted visitors – such as bacteria and parasites – by engulfing and chemically destroying them. They also rid their domicile of foreign debris.

Like any good butler, they wait quietly until called upon. Only when summoned to action do they show force. It now appears that the pent-up chemical fury they harbor can, once unleashed, compound the liver injury they had been mobilized to prevent, notes I. Glenn Sipes of the University of Arizona in Tucson.

Three reports of vitamin A's potentiation of liver toxicity by his team appear in the April TOXICOLOGY AND APPLIED PHARMACOLOGY. Two other reports in the journal also characterize this Jekyll-to-Hyde transformation by Kupffer cells.

Rats exposed to a single minimally toxic dose of carbon tetrachloride (0.15 milliliter per kilogram of body weight) exhibit a small amount of damage in key cells in the liver, known as hepatocytes. Sipes and his co-workers compared that damage to what they saw in animals who received up to 250,000 international units of vitamin A (retinol) per kilogram of body weight daily.

In animals pretreated with vitamin A for one day to five weeks prior to carbon-tetrachloride exposure, Sipes says, "the previously minimal injury has exploded to look like we've given a huge dose of carbon tetrachloride." Vitamin pretreatment did not affect the type of cell affected or region of injury, only the magnitude of damage.

In similar tests, rats received toxicants – acetaminophen, allyl alcohol, and a poison produced by *E. coli* bacteria – which caused very different patterns of liver damage. Again, pretreatment with vitamin A exaggerated the specific pattern of damage characteristic of each agent.

Sipes recalls being puzzled about why systemic delivery of the vitamin should foster selective damage only to those cells targeted by another toxic chemical. Eventually, members of his team spotted structural changes in Kupffer cells from vitamin-A-treated rats. The changes signaled the Kupffers were primed to release biologically damaging free radicals.

So Sipes' team performed their experiments again. But this time they added one of three different chemicals to shut down Kupffer-cell activation. And each time vitamin A's exaggeration of carbon tetrachloride's toxicity disappeared. Concludes Sipes, "Small amounts of carbon tetrachloride somehow triggered primed Kupffer cells to over-respond" in their production of cell-killing free radicals.

"We got into these studies because large doses of [vitamin-A-like] retinoids are being used in cancer therapy," Sipes says. Future studies will explore whether lowering doses of both the vitamin (to levels more commonly consumed by humans) and a toxic chemical also causes damage.

But the biggest take-home message, Sipes says, is the value of animals in studying potentially toxic mixtures. Popular *in vitro* tests using only one type of cell would miss this new effect, he says, since the toxicity depends on the interaction of different cell types.

Though such research into the effects of chemical mixtures "is really at an embryonic stage," it is essential for teasing out risks people face from exposures to a complex cocktail of agents in the real world, points out Raymond S.H. Yang of Colorado State University in Fort Collins.

– J. Raloff

Pediatric exam foreshadows vision problems

Eye doctors may soon be able to predict an infant's risk of developing nearsightedness later in life, thanks to the unexpected results of a long-term study of visual development. The study raises the hope that an eye exam soon after birth will enable ophthalmologists to prevent myopia and other visual problems.

Eighteen years ago, researchers at the Massachusetts Institute of Technology began recruiting newborns for a study of how normal vision develops. The group used a retinoscope to detect visual defects, including myopia. People with myopia can see objects close at hand, but distant objects appear blurry. To the investigators' surprise, many of the infants were myopic.

Those findings prompted the team to keep track of the infants, says Jane Gwiazda, a psychologist at MIT and one of the researchers. They have since taken nearly 8,000 vision measurements from more than 400 children.

The team discovered that nearsightedness improves dramatically during the first five years of life. That finding fits with the observation that very few children in kindergarten have vision problems.

However, the MIT data reveal that some children start showing signs of myopia between age 6 and 12. More significant, the children who had myopia as infants also had the highest risk of developing this problem later, Gwiazda says. She presented the results of the study at the Science Writers Seminar in Ophthalmology held this week in Universal City, Calif.

The findings suggest that a child's first eye exam ought to take place at least six months after birth but before age 1. The standard recommendation to have an eye exam at school age is unlikely to yield useful information about a child's future risk of myopia, she says.

Children with myopic parents have a greater chance of developing this visual problem, the study shows. When both parents were myopic, 42 percent of their children became nearsighted; if only one parent was nearsighted, the incidence of myopia in offspring dropped to 22.5 percent; and if neither parent suffered myopia, only 8 percent of their children were nearsighted, Gwiazda says.

Many researchers postulate that close-distance work, such as reading and writing, which increases when children enter school, may trigger symptoms of myopia. In fact, some ophthalmologists believe that society's reliance on computers and its penchant for television viewing have also contributed to the disorder. The link between close-distance work and myopia remains controversial, however, Gwiazda notes.

The study's findings raise the question of whether physicians can prevent nearsightedness in children at risk. Current efforts start well after school age, but the new results suggest that preventive measures could begin much earlier, perhaps in infancy.

In a related report, ophthalmologist Joseph M. Miller of the University of Arizona in Tucson stressed the need for early detection of amblyopia, another visual defect in children. A child with amblyopia, or lazy eye, has one eye that is misaligned. To prevent double vision, the brain ignores the image from the skewed eye. The result is that vision in the affected eye deteriorates, often to the point of legal blindness. At the seminar, Miller reported on a computerized method of image analysis that detects amblyopia in very young children.

Right now, there is no way to stave off nearsightedness, even if at-risk infants are identified, Gwiazda admits. She hopes that research into the cause of myopia will lead to preventive treatments for this common visual problem. By contrast, early diagnosis of amblyopia could lead to more timely treatment, Miller says. Prompt treatment, usually with an eye patch, can restore perfect or near-perfect vision in an affected child, he says.

– K.A. Fackelmann

Kinship ties influence behavior, morphology

Scientists often talk about animals recognizing and consequently helping their kin. Such aid benefits the helper by promoting the spread of genes the relatives have in common. Two new reports show how organisms practice this concept, known as inclusive fitness, sometimes carrying it to extremes.

Behavioral ecologists have demonstrated that young tiger salamanders in Arizona can transform into voracious cannibals, especially in the company of strangers. In addition, the cannibals prefer to devour those young that are least closely related to themselves, says David W. Pfennig of Cornell University.

For their experiments, Pfennig and James P. Collins of Arizona State University in Tempe placed larvae from eight families in one of three situations. In the first, they set up 80 aquariums, each with 16 larvae from the same brood. An additional 40 aquariums each contained eight siblings from one family and eight from a second family, though sometimes the second eight were cousins of the first. Another 40 aquariums contained a pair of siblings from all eight families.

Normally, these gilled larvae munch on invertebrates, but in about 85 percent of the two mixed groups, one salamander quickly grew much larger than the rest. It also developed a broad snout and hard, bony plates with long, curved teeth well suited for catching smaller salamanders. Cannibals developed only 40 percent of the time in single-family aquariums and tended to do so later, when their siblings were less vulnerable, Pfennig and Collins report in the April 29 NATURE.

They also discovered that the cannibals preferred unrelated salamanders to cousins and cousins to siblings. "They can discriminate kin from nonkin," says Pfennig. The research shows that this information affects not only behavior — the cannibal chooses to eat unrelated larvae, leaving more resources available to siblings — but also morphology, something researchers tend to think of as less plastic than behavior, Pfennig notes.

Pfenn. Collins/NATURE

Oversized salamander devours a fellow larva, most likely unrelated.

"Their findings are exactly what you'd predict from inclusive fitness [theory]," comments George J. Gamboa of Oakland University in Rochester, Mich.

Gamboa does not know of other examples where kinship affects growth or development in animals, including humans. Pfennig cites two studies showing that plants grow better when potted with kin.

European scientists have observed a slightly more puzzling example of inclusive fitness among pilot whales. These whales travel in pods that sometimes number more than 100 males and females with their young. Whales within a pod are closely related, but the pod's males do not father the young in the group, reports Bill Amos, a geneticist at the University of Cambridge in England. He and Christian Schlötterer and Diethard Tautz from the University of Munich in Germany performed extensive analyses of genetic material obtained from two pods caught off Denmark by Faeroe Island fishermen, one of the few groups to hunt these marine mammals.

In 1991, Amos reported that each pod represents one extended family and that adult males and females stay close to their mothers. Now, an examination of DNA from 34 fetuses from those pods has revealed that outsider males parented at least 33 of them. Also, it seems that those outsiders belonged to groups of related males, the researchers report in the April 30 SCIENCE.

Amos and his colleagues suggest that males find mates when two pods intermingle — boaters have observed aggregations of more than 1,000 pilot whales — or that the males may occasionally wander off for a brief mating foray.

In some social mammals, young adult males tend to leave their family units altogether. If males stay with their relatives, they form a social structure in which a few dominant males do almost all the mating.

Because they encounter enough other pods, male pilot whales, and perhaps killer whales, may promote their genes best by spending their time helping their mothers and sisters and mating outside the pod, the scientists conclude.

— E. Pennisi

Dyslexia risk linked to summer births

A new study suggests that children born in summer months stand the greatest chance of developing dyslexia, a reading disorder that may afflict up to 9 percent of children in the United States.

This seasonal pattern may result from the exposure of women in the second trimester of pregnancy to influenza or other viral diseases during late winter, theorize Richard Livingston, a psychiatrist at the University of Arkansas for Medical Sciences in Little Rock, and his colleagues. Viruses may subtly derail the paths traveled by brain cells during that crucial stage of fetal development, the researchers maintain.

The finding of seasonal clustering requires confirmation by other investigators, but it coincides with evidence implicating viruses and other sources of potential harm to the fetal brain as contributing causes of schizophrenia (SN: 9/19/87, p.180), autism, mental retardation, and hyperactivity.

"Second-trimester viral exposure is presently the most attractive hypothesis to account for a seasonal birth pattern in dyslexia," the researchers conclude in the May JOURNAL OF THE AMERICAN ACADEMY OF CHILD AND ADOLESCENT PSYCHIATRY.

However, brain changes that lie behind dyslexia should prove "significantly more discreet" than those presumed to foster a severe mental disorder such as schizophrenia, Livingston notes.

Livingston and his co-workers reviewed data on 585 boys born between 1948 and 1970 who were referred to a university psychiatric clinic, often for behavior or learning problems. Boys ranged in age from age 9 to their early 20s. A total of 173 suffered from dyslexia, defined as a reading score on standard tests falling at least two years behind the expected level despite a normal IQ.

Too few dyslexic girls attended the clinic to allow for an analysis of their risk of developing the disorder.

Overall, boys born in May, June, or July displayed more than twice the risk of developing dyslexia as boys born in any other month, the investigators found. Births in these three months accounted for 40 percent of all instances of dyslexia, Livingston says.

The risk of being born dyslexic peaked during particular spans of years, the psychiatrists note. The most pronounced risk was from 1950 to 1954, when summer births accounted for seven in 10 cases of dyslexia. A review of Arkansas state health records indicates that the greatest number of cases of influenza and measles occurred in the years during which the most dyslexics in the sample were born, Livingston says.

Complications other than viral exposure may disturb fetal brain development and foster dyslexia among children born in non-summer months, he adds. For instance, compared with summer-born dyslexics in the Arkansas sample, dyslexic boys born from November to January experienced substantially more premature births, size abnormalities at birth, and birth-related head injuries.

"I suspect different types of early brain insults can cause dyslexia," Livingston says.

— B. Bower

Interference of light scattered by two ions

English physicist Thomas Young was the first to demonstrate convincingly that light behaves like a wave. In his famous 1801 experiment, he allowed light to pass through a pair of closely spaced pinholes onto a screen. Each pinhole caused the light to fan out into a wide beam. Where the two beams overlapped on the screen, Young saw bands of bright light alternating with bands of darkness.

Now, a team of physicists has observed for the first time a similar interference pattern created by laser light deflected from two atomic ions held nearly stationary in a special trap. Measurements of the scattered light intensity reveal a pattern of bright and dark bands, or fringes, corresponding to where light waves have either reinforced or canceled each other.

However, when the researchers used detectors that are sensitive to the direction of polarization of the scattered light, they saw an interference pattern for one type of polarized light but no pattern of intensity variations for the other type. The absence of an interference pattern in the latter case can be interpreted as evidence that light also behaves like a particle (or photon).

Thus, in a curious twist on the quantum-physics notion of wave-particle duality, the researchers can demonstrate either the particle or the wave nature of light in the same experiment simply by picking a detector sensitive to the appropriate kind of polarized light.

"We can now have a 'switch' to decide whether we are going to extract the particle-like or wave-like character [of the scattered light]," says Ulli Eichmann of the National Institute of Standards and Technology in Boulder, Colo.

Eichmann and his co-workers describe their experiment in the April 19 PHYSICAL REVIEW LETTERS.

The researchers performed their experiment using two singly charged mercury ions held in place by radio waves. A laser beam tuned to a wavelength of 194 nanometers cooled the ions, keeping them from jiggling excessively. The same beam also served as the light source for the interference experiment.

When Eichmann and his colleagues observed the laser light scattered by the trapped ions, they saw variations in light intensity characteristic of an interference pattern. Moreover, nudging the ions closer together increased the spacing of the pattern's fringes. In other words, the two ions acted just like the pinholes of Young's experiment.

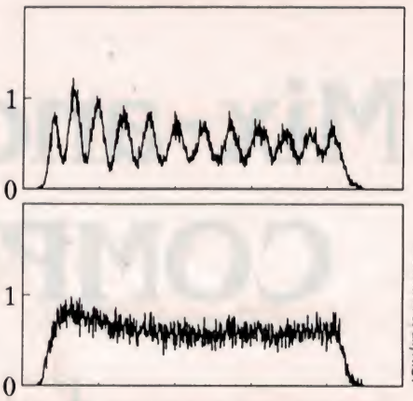
However, the incoming laser light — which is initially polarized so that its electric field points in a particular direction — can interact with the ions in two different ways. In one case, the laser light causes no change in an ion's state and the scattered light remains linearly polarized. Which ion scattered a particular photon can't be determined.

"Quantum mechanics therefore predicts that interference must be present in the light scattered from the two ions," the researchers note.

In the other case, the light excites an ion from its ground state to a slightly higher energy level and the scattered light no longer has a preferred polarization direction. By looking for the excited ion, researchers can, in principle, identify which ion interacted with a particular incoming photon.

"This allows us . . . to distinguish the scattering [ion] from the 'spectator' [ion] and hence to determine which path the photon traveled," Eichmann and his colleagues say. "Consequently, there is no interference in the light scattered from the ions."

Having demonstrated that two ions can produce a scattered-light interference pattern, the researchers suggest that interference measurements themselves may provide a useful alternative method of determining the temperatures and separations of ions held in traps. They are now studying the pattern created by three trapped ions. *— I. Peterson*



Eichmann et al./NIST

When detecting linearly polarized light, the researchers see intensity fluctuations characteristic of an interference pattern (top). No interference pattern appears when they observe circularly polarized scattered light (bottom).

Unusual tubes emerge from boron nitride

Chemists seeking an alternative method for making boron nitride — a substance used to create hard, diamond-like materials, face powders, and fibers for composite materials — have discovered a new form of the material: microscopic tubes.

"At this point, I think the tubular form is a curiosity," says Sheldon G. Shore, one of the group of chemists at Ohio State University in Columbus who found the tubules. "But it does suggest the possibility that carbon is not the only element that can be made into tubes."

Scientists aiming ultimately to make microscopically thin wires succeeded recently in making superstrong nanometer-size tubes from carbon (SN: 4/3/93, p.214). Boron compounds often resemble those made of carbon (SN: 6/20/92, p.406).

Shore and his co-workers were surprised to see these boron nitride tubes, for two reasons. First, the tubes emerged out of boron nitride's amorphous phase in an ordered, parallel alignment. Second, the boron nitride tubes were about 100 times larger than their carbon counterparts and, unlike them, apparently formed without the aid of a catalyst. The formation mechanism of these unusual tubes, which lack the layered crystalline structure of graphite carbon, continues to puzzle the researchers, Shore says.

In the April 30 SCIENCE, Shore and his colleagues describe how they synthesized amorphous boron nitride with a new procedure involving an explosive reaction between B-trichloroborazine and cesium metal at 125°C. They then heated this material to 1,100°C for 24 hours. The tubes were revealed by scanning electron microscopy (SEM).

SEM images show (top) typical boron nitride tubes 50 to 100 microns long and (bottom) the tube openings, some as much as 3 microns wide.

Robert T. Paine of the University of New Mexico in Albuquerque says the team made a "fundamentally interesting observation." But, he adds, "This is an unusual form of the material, and its utility remains to be seen."

Indeed, Shore's group now intends to study the tubes' physical properties. They also plan to try heating the amorphous boron nitride further—to 1,400°C—to see if they can create highly ordered, graphite-like tubes. *— K.F. Schmidt*

Mix-and-Match COMPUTING

Scientific supercomputing without supercomputers

NCSA

By IVARS PETERSON

"So many galaxies . . . so little time."

Astrophysicist Margaret J. Geller's lament could just as easily have come from other researchers similarly mired in mountains of data. Just replace "galaxies" with such terms as genes, [illegible] researchers, the "mix-and-match" mode of computing that results from linking different machines provides an attractive, cost-effective alternative for relieving the work load of the heavily burdened supercomputers.

Over the last decade, Geller and her co-workers at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., have painstakingly and systematically recorded the redshifts of thousands of galaxies. Redshifts are increases in the characteristic wavelengths of light emitted by stars. Caused primarily by the expansion of the universe, they allow researchers to estimate the distances of galaxies from Earth. By combining these distance measurements with a database of galaxy positions in the sky, astronomers can construct step by step a three-dimensional map of the distribution of galaxies in the universe.

Geller and her colleagues have measured the redshifts of galaxies that lie within long, thin strips across the sky. Taken together, these wedge-shaped slices reveal that galaxies tend to clump into thin shells, like the walls of enormous soap bubbles hundreds of millions of light-years across (SN: 11/25/89, p.340).

To obtain these insights, the researchers used computers that provide three-dimensional views of the data. But it took a lot of experience and manipulation of the pictures on the computer screens to pick out the salient features.

As an experiment in alternative methods of visualizing huge amounts of data, Geller recently worked with graphics specialists at the National Center for Supercomputing Applications (NCSA), located at the University of Illinois at Urbana-Champaign, to animate the redshift survey. Using images of real galaxies, the NCSA team created the illusion of a journey through the universe.

This sequence became part of a 40-minute film illustrating how science is done. "I've been showing the film to standing-room-only audiences at various universities," Geller says. "People react to the graphics in an extraordinary way."

The team also converted one slice of the redshift data into a virtual-reality environment (SN: 1/4/92, p.8). By looking through a stereoscopic viewer mounted on a boom, Geller could inspect computer-generated images of the galaxies, and the scene would change as she moved her head or body.

"We were able to navigate through the slice . . . without having to have somebody preprogram the path for us," Geller says. "It certainly was extraordinary to have the sensation of really traveling through [the slice] and being in command."

"Had we had [this kind of capability] when we first obtained the data, there are a lot of things we would have known more quickly," she adds.

Geller's experience at NCSA illustrates one aspect of the changes that have occurred in supercomputing at the four national supercomputer centers, which were established by the National Science Foundation in 1985 (SN: 3/2/85, p.135).

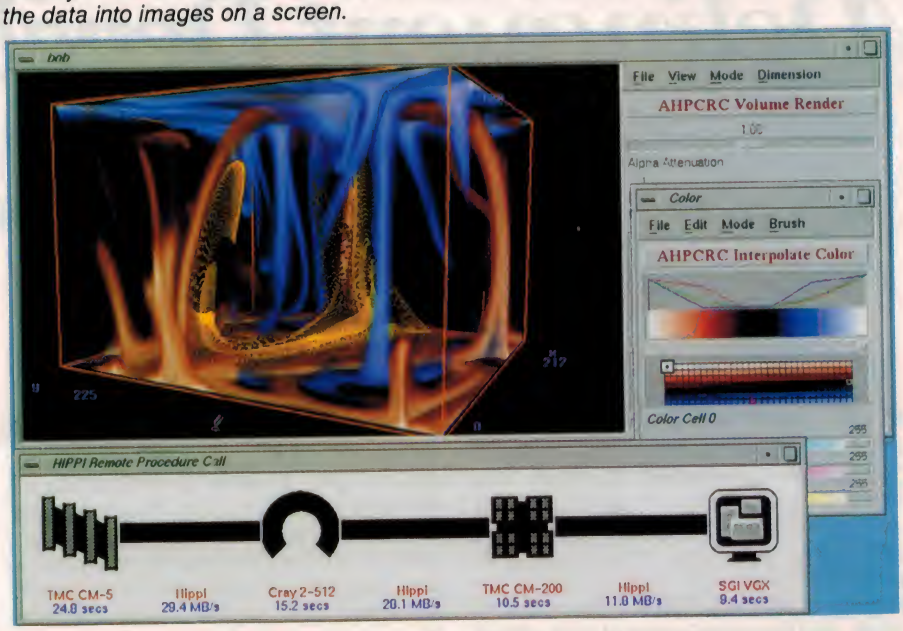
Located at the University of Illinois, Cornell University, the University of Pittsburgh, and the University of California, San Diego, the centers originally were geared toward testing the power and versatility of supercomputers for scientific computation. Over the intervening years, these powerful machines attracted thousands of users — so many that researchers now must sometimes wait days or weeks to run their programs.

At the same time, it became evident that additional, specialized computers were needed to handle the prodigious output of the supercomputers. So the centers gradually added various machines for such tasks as visualization and graphics, and hired the staff required to support these activities. This approach gave researchers like Geller access to graphics and visualization techniques normally affordable only to Hollywood studios or large oil companies.

Now, the primacy of the traditional supercomputer — a single, enormous, multipurpose machine — is itself being challenged. Faced with supercomputer prices ranging from $15 million to $30 million apiece, many groups are looking

Computer-generated images and virtual-reality technology allow a user to view the distribution of galaxies in the universe from many different perspectives. The user can zoom in on individual galaxies or navigate around enormous clusters.

In a recent demonstration of mix-and-match computing, three linked supercomputers at the Minnesota Supercomputer Center, Inc., performed the calculations needed for a study of thermal convection in Earth's mantle. A graphics computer then converted the data into images on a screen.



MSCI

High-performance communications links play a crucial role in network computing. This illustration shows the volume of incoming traffic for September 1991 at various points along NSFNET's high-capacity lines. The traffic ranges from zero bytes (purple) to 100 billion bytes (white).

Donna Cox and Robert Patterson/NCSA

for alternative approaches for increasing computational capacity.

"We're at a critical moment in supercomputing," says Larry L. Smarr, director of the NCSA.

One possibility being explored is the linking of workstations — the kind of microprocessor-based computers that most researchers have sitting on their desks — into coordinated clusters to perform certain kinds of computations. Although such networks may take longer to solve a particular problem, the total cost of the machines involved is far less than the price of a single conventional supercomputer.

Moreover, because these desktop machines often sit idle for lengthy periods, connecting them into networks so that they can work together on large problems increases their effectiveness. Such arrangements also permit greater flexibility in selecting the number and types of computers required for a particular application.

Last year, a physicist and two computer scientists provided one of the more dramatic examples of what a collection of high-performance computers, scattered around the United States, could accomplish when linked together.

Hisao Nakanishi of Purdue University in West Lafayette, Ind., was interested in the physics underlying what happens to the shape of polymer strands passing through a membrane or trapped in a porous material such as sandstone. Confined to the material's pores, the chains of molecular units that make up polymers bend and twist in ways that differ from those possible in a liquid.

Nakanishi turned to Vernon Rego of Purdue and Vaidy Sunderam of Emory University in Atlanta for help with the computer simulations he needed to investigate this aspect of polymer physics. The team concentrated on the question of how the straight-line, end-to-end length of a polymer increases as the polymer grows into a chain and eventually traverses a cube containing an array of randomly placed obstacles. Of special interest was the "critical" case in which the cube contains just enough obstacles to provide only a single connected region comprising all the open paths along which the polymer chain can grow from one side of the cube to the other.

The researchers realized that doing the simulation on a scale large enough to yield meaningful results on a single Cray supercomputer would require several days to several weeks of computer time. As an alternative, they developed special software that treats a cluster of separate computers as a single machine, with computations divided among the participating computers.

Nakanishi and his collaborators had access to computers at Purdue, Emory, Florida State University, California Institute of Technology, Oak Ridge (Tenn.) National Laboratory, and the University of Tennessee. The most elaborate arrangement they tested combined 48 IBM RS/6000 computers, 80 Sun Sparc workstations, and two Intel i860 hypercube computers. In 10 minutes, this configuration did computations that would take three hours on a Cray Y-MP.

That was good enough for the Purdue-Emory group to earn first prize in the 1992 Gordon Bell competition. This award recognizes significant achievements in the application of high-performance computers to scientific and engineering problems. The judges describe the winning entry in the January issue of COMPUTER.

Continued on p. 284

Delinquent Developments

Career criminals and temporary law-breakers may cross paths as teenagers

By BRUCE BOWER

Dunedin lies at the southern end of New Zealand, nearly half a world and a far cry from the gritty, sometimes grim realities of life for youngsters growing up in many U.S. cities. Yet a group of more than 1,000 boys and girls born in Dunedin 21 years ago now offers behavioral researchers provocative clues to the ways in which the timing of puberty, enduring personality traits, and the social world of high school work together to foster different types of juvenile delinquency.

Indeed, only by tracking people from birth through adulthood can scientists unravel the forces that produce lifelong antisocial and criminal behavior, contend Terrie E. Moffitt and Avshalom Caspi, two psychologists at the University of Wisconsin-Madison. Such longitudinal studies may also help delineate why many teenagers make occasional forays into delinquency but avoid a life of crime and stormy personal relationships, they add.

Moffitt and Caspi have collaborated with New Zealand researchers who organized the Dunedin project — formally known as the Dunedin Multidisciplinary Health and Development Study — to analyze data on psychological and behavioral development in the sample.

The Dunedin findings emerge at a time of intense controversy regarding research into crime and violence. Last year, the head of the then Alcohol, Drug Abuse, and Mental Health Administration resigned his position amid controversy over his statements linking inner-city crime to the behavior of monkeys; soon thereafter, federal officials withdrew funds for an upcoming conference addressing genetic influences on crime.

Nearly all criminologists, psychologists, sociologists, and other investigators — including those who organized the ill-fated meeting on the genetics of criminal behavior — routinely reject the idea of a "crime gene" or "born criminals." At the same time, they note that some partially inherited traits, such as intelligence and temperament, influence the likelihood that individuals will participate in criminal acts.

For instance, in their book *Crime and Human Nature* (1985, Simon & Schuster), political scientist James Q. Wilson of the University of California, Los Angeles, and psychologist Richard J. Herrnstein of Harvard University argue that inherited elements of human nature develop in an intricate web of family and social encounters, and that this complex process helps determine how people choose between the consequences of crime or its alternatives.

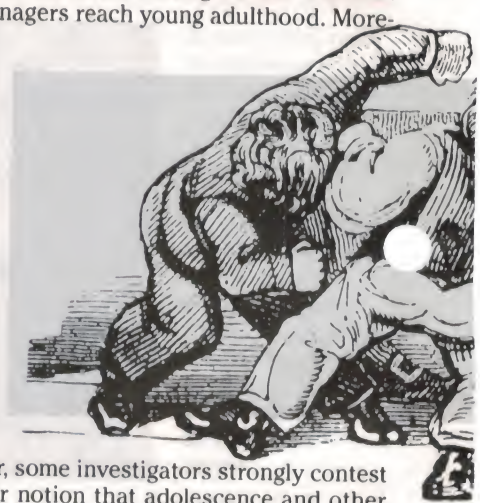
"Some traits or dispositions are inherited, but the continuity of behavior, including antisocial activity, is maintained by social contexts and other aspects of the environment," Caspi contends.

Caspi and Moffitt approach the Dunedin sample from this perspective. In an article accepted for publication in PSYCHOLOGICAL REVIEW, Moffitt argues that the findings she has made so far, along with previous data on national crime rates and child development, indicate that teenagers who engage in at least some delinquent acts represent the large majority of adolescents and travel either of two diverging paths toward adulthood.

Poor self-control and aggressive behavior typify virtually the entire lives of a small group of hard-core delinquents in New Zealand, and probably elsewhere, Moffitt contends. A much larger group takes up delinquency as an adolescent avocation because these individuals see no other means to demonstrate their independence and grab a bit of grown-up status, at least until jobs, marriage, and other gateways to adulthood offer greater rewards. For them, delinquency helps bridge the five- to 10-year time warp between the "now" of physical and sexual maturity and the "later" of social maturity, Moffitt argues.

Dunedin-born youngsters who spent their childhoods embroiled in behavioral and school problems and who entered puberty earlier than most of their peers proved the most likely to embrace teenage delinquency, often with a ferocity unmatched by their fellow adolescents, Caspi and Moffitt assert. To help explain this tendency, the researchers theorize that each person responds to new, ambiguous situations for which no clear behavioral guidelines exist (for instance, the sudden social pressures to start dating and have sex, applied to girls experiencing early puberty) by leaning more than ever on familiar, well-practiced styles of dealing with others.

Many of Caspi and Moffitt's predictions about the natural history of antisocial behavior await testing as the Dunedin teenagers reach young adulthood. Moreover, some investigators strongly contest their notion that adolescence and other social transitions magnify an individual's basic personality traits.



Still, "the New Zealand study exemplifies a trend in developmental psychology toward looking at different pathways by which adolescents arrive at delinquency, depression, eating disorders, and other conditions," says Jeanne Brooks-Gunn, a psychologist at Columbia University in New York City. "Cross-sectional [one-time] studies tell us nothing about how kids got to where they are."

The bruising developmental pathway traversed by hard-core teenage delinquents in the Dunedin sample bodes ill for their futures and for those of their spouses and children, Moffitt suspects. In fact, many of these individuals may end up as "career criminals," the approximately 5 per cent of the population that commits more than half of all recorded adult crimes, Moffitt contends. Their flair

for aggression and for acting on impulse also probably ignites all sorts of interpersonal mayhem, including child and spouse abuse, she adds.

What Moffitt dubs "life-course persistent antisocial behavior" begins in early childhood or even in the womb, in her view, with poorly understood forms of subtle brain damage that foster two major childhood problems: language difficulties that disrupt listening, reading, writing, and verbal memory; and the lack of attentiveness and self-control associated with the psychiatric condition known as attention-deficit hyperactivity disorder (ADHD).

Maternal drug use during pregnancy, poor prenatal nutrition, exposure to lead or other toxic substances, and child abuse or neglect are among the many possible culprits that can sabotage fetal and infant brains, Moffitt notes. Responsive parents may help a toddler leap over early neural stumbling blocks, but given harsh conditions at home, at school, and in the neighborhood, a child's personal and academic problems usually expand while options for change shrink, she argues.

shoplift and skip school at 10, and sell drugs and steal cars at 16. They will probably rob and rape at 22 and embezzle at work and beat their wives at 30, Moffitt predicts.

But these dedicated delinquents got plenty of company from their male compatriots during adolescence, she points out. Pervasive delinquency appeared among one-third of the New Zealand 15-year-olds; when interviewed at age 18, fewer than 1 in 10 boys reported refraining entirely from delinquent acts.

Boys whose delinquency bloomed in their teen years often limited such behavior to particular situations, Moffitt observes. For example, some shoplifted in stores and used drugs with friends, but continued to obey the rules at school.

These youngsters respond to a "maturity gap" that many adolescents must cross in modern societies, Moffitt theorizes. Since the mid-1800s, improved nutrition and health care have lowered the average age of puberty — a trend most clearly seen in the gradually dropping average ages at which menstruation begins among girls — while technological advances have increasingly delayed the average age at which people enter the work force. Prior to the last two centuries, youths typically achieved adult status during the teen years, often performing clear rites of passage before entering a craft or assuming responsibility for a family business, Moffitt notes.

For five to 10 years, most of today's teenagers carry the weight of biological maturity without the balance of adult responsibilities and privileges, she asserts. Certain types of delinquent behavior thus gain favor as an avenue to adult power and independence. Perhaps adolescents who have developed relatively normally but find themselves mired in the maturity gap selectively mimic the well-practiced delinquency of "life-course persistent" youths, she proposes. After all, members of this latter group often garner considerable incomes from their illegal activities, sire children out of wedlock, and sport other symbols of having passed straight into the adult world.

If every curfew violated, drug taken, car stolen, and baby conceived serves as a statement of personal independence among "adolescence-limited" delinquents, Moffitt says, then these actions become increasingly rewarding unless alternative sources of adult status take their place, such as landing a steady job and gaining financial responsibility for one's family.

The two developmental paths trod by teenage delinquents sometimes take unexpected turns, she points out. A "life-course persistent" boy, for instance, may happen upon an adult mentor or a devoted grandparent who shepherds him toward academic achievement and job success. And an "adolescence-limited" delinquent who lives on the mean streets of a large city may join a gang and participate in crimes that lead to a prison record and continuing problems getting an education and a good job.

But early childhood personality styles frequently lead in a predictable way toward either antisocial or well-adjusted adult behavior, Moffitt asserts.

"Some traits or dispositions are inherited, but the continuity of behavior, including antisocial activity, is maintained by social contexts and other aspects of the environment." — Avshalom Caspi

An analysis of 435 of the Dunedin boys — whose behavior was evaluated through ratings made by the boys, their parents, and their teachers every other year beginning at age 5 — supports Moffitt's theory. These results first appeared in the June 1990 CHILD DEVELOPMENT.

Among the 15-year-old boys, those who frequently engaged in delinquent acts and showed signs of ADHD scored extremely poorly on tests of verbal intelligence and reading ability, while scoring high on family adversity (indicated mainly by low parental income, low maternal IQ, poor maternal mental health, and having a single parent). From age 3 on, they lagged far behind their counterparts on tests of general intelligence and motor coordination. Reading failure dogged them throughout their school years, while their fighting and delinquency progressively worsened.

These boys, who made up 5 percent of the male sample, apparently mold their penchant for violence and misbehavior around the social opportunities at hand, Moffitt says. They bite and hit at age 4,

Although epidemiologic studies and crime statistics from several countries indicate that the vast majority of teenagers of both sexes commit an illegal act at some time, researchers know little about youngsters who shun delinquency, Moffitt adds.

In some cases, late puberty may allow a teenager to skip the maturity gap and remain crime free, she suggests. Evidence supporting this proposal comes from an analysis of delinquency among 348 New Zealand girls, reported by Caspi and Moffitt in the July 1991 JOURNAL OF PERSONALITY AND SOCIAL PSYCHOLOGY.

Girls who did not menstruate by age 15 tended to avoid delinquency of any kind. Those who began menstruating by age 12 proved much more likely to get in fights, steal, use alcohol and illicit drugs, and commit other delinquent acts.

Early onset of menstruation sparked the most delinquency and emotional difficulties among girls who had displayed behavior problems throughout childhood, Caspi and Moffitt found. It appears that early puberty rudely thrusts girls, as well as boys, into the maturity gap and magnifies the misbehavior of those predisposed to delinquency, the researchers argue.

At the same time, girls show considerable sensitivity to the social context of high school. A further breakdown of the New Zealand data, reported by Caspi, Moffitt, and two co-workers in the January DEVELOPMENTAL PSYCHOLOGY, revealed that girls experiencing early puberty engaged in more antisocial behavior if they attended a coed high school rather than an all-girl facility. Late-maturing girls displayed little taste for delinquency at either type of school.

Overall, problem behaviors turned up among a small minority of the 165 New

Zealand girls who attended single-sex schools, whereas stealing, drug use, frequent sexual intercourse, and fighting occurred much more often among the 132 girls enrolled at coed schools.

Older students at coed schools, particularly boys, may demonstrate to younger girls the ways in which delinquency severs childhood apron strings and secures, at least from a teenage perspective, adult privileges, the researchers argue.

Few U.S. students attend single-sex schools, which recruit a select group to expensive private institutions, religious schools, or military facilities. But New Zealand maintains many all-girl public secondary schools, which attract students largely on the basis of academic reputation, location, and prior attendance by other family members, Caspi notes. For all its differences from the United States, he says, New Zealand offers a relatively controlled environment in which to study the ways in which puberty interacts with the social realm of high school.

Related findings emerge from a study of 125 U.S. girls attending coed schools and tracked from age 11 to 15 by Brooks-Gunn and her colleagues. Depression, eating problems, and delinquency appeared most often among those who reached puberty early and who encountered a greater number of stressful events than their peers, the researchers assert in *Stress and Coping in Infancy and Childhood* (1992, Tiffany M. Field *et al.*, editors, Lawrence Erlbaum Associates, Hillsdale, N.J.). Such events covered a broad spectrum, including parental divorce, getting a boyfriend for the first time, losing a school election, and not making an athletic team.

Regardless of their age at puberty or the type of high school they attend, some teenagers may harbor personality traits that prove incompatible both with delinquency and with emotional well-being, Moffitt says.

For instance, in a study of 101 boys and girls living in the San Francisco Bay Area and followed from age 3 to 18, Jonathan Shedler and Jack Block – both psychologists at the University of California, Berkeley – found that those who occasionally experimented with drugs as teenagers exhibited the best psychological adjustment. Experimenters used marijuana no more than once a month and had tried no more than one other illicit drug. Frequent drug users, who smoked marijuana once a week or more and had tried at least one other illegal drug, displayed few friendships with their peers, poor self-control, and emotional distress. Teenagers who had never tried marijuana or any other illegal drug exhibited anxiety, difficulty expressing emotions, and few social skills.

In each of the three groups, individuals often carried over their prominent personality traits from childhood, Shedler and Block report in the May 1990 AMERICAN PSYCHOLOGIST.

Drug use certainly does not improve mental health, and it proves highly destructive for frequent users, Shedler and Block point out. "But for adolescents more generally, some drug experimentation apparently does not have psychologically catastrophic implications," they conclude.

Moffitt considers these data congenial to her theory of dual developmental paths leading to teenage delinquency. Drug experimentation wreaks further emotional havoc on "life-course persistent" youths, she argues, but it fails to drag down basically healthy teens navigating the maturity gap. Meanwhile, some adolescent abstainers indulge in their lifelong habit of social isolation and anxiously shrink from the defiance of drug use.

Of course, teenage delinquency responds to other influences, including poverty, unemployment, rising numbers of divorces, lack of parental supervision, and violence displayed through the media. But Moffitt asserts that these factors cannot explain why crime rates charted in the United States and England, as well as in New Zealand, dramatically rise during adolescence and then reverse course as teens reach young adulthood.

Jack Block says participants in the California longitudinal study, which he organized with his late wife, Jeanne H. Block, bear some similarity to the New Zealand youngsters. A small group of Bay Area teens parlayed childhood behavioral and emotional problems into serious adolescent delinquency, he says, while many well-adjusted teenagers briefly sampled various misbehaviors as part of a search to define themselves.

Block disputes Caspi and Moffitt's theory, however, that deep-seated personality traits intensify during adolescence and other ambiguous transitions. Instead, he argues, a teenager's underlying personality may emerge from the shadows for the first time as parents and other adults begin to relax the behavioral guidelines and restrictions of childhood.

Moreover, some unstructured situations evoke a highly consistent response – caution and noncommittal behaviors – from a wide range of people, he says.

The resolution of debates over the relationship of personality development to delinquency depends on continued longitudinal research, such as the New Zealand and California studies, Block says. Few such projects exist, he asserts, because they are logistically complex, costly, and incapable of generating "fast" data for scientists anxious to publish papers and gain academic tenure.

Moffitt notes another obstacle to unraveling the development of delinquency: Researchers possess a "woeful" lack of knowledge about the meanings that teenagers themselves attach to puberty, high school, and various types of delinquency.

"We can't understand adolescence-limited delinquency without first understanding adolescents," she remarks. □

Continued from p. 281

Although the Purdue-Emory scheme represents an important first step, the logistics of handling such a network of computers remains exceedingly complicated. Indeed, the software required for binding the system together represents the main bottleneck. In many instances, software deficiencies keep these systems from running as efficiently as possible.

Nonetheless, researchers are optimistic that such problems will eventually be solved. Smarr envisions the development of a national "metacomputer" – an array of different types of computers linked by a high-speed, high-capacity network to act as a single computer.

In a sense, each national supercomputing center already acts as a metacomputer, invisibly shuffling programs and files from supercomputer to massively parallel machine to graphics computer to mass-storage device to workstation. Ordinarily, users need specify only what they would like done, and the center's software takes care of the details of when, where, and how.

Smarr would like to see this concept extended to networks of computers on a national scale. By automatically adjusting to the power and speed required for solving a particular problem, such systems would provide greater flexibility for scientists working on a wide range of applications.

"But we're not there yet," Smarr cautions.

As one step toward "scalable supercomputing" and the development of a national information infrastructure, the four national supercomputer centers last year announced the formation of a national MetaCenter (SN: 11/28/92, p.374). Center staffs are now working together to establish standards so that people can use any computer, or set of computers, at any center.

"This also allows the centers to specialize, rather than trying to be everything to everybody," Smarr says.

In response to the rapid changes in computer technology, the National Science Foundation is reviewing the role of high-performance computing in scientific research and reevaluating the rationale for the national supercomputing centers. Chaired by Lewis Branscomb of Harvard University, the panel charged with the review expects to present its report and recommendations later this month. □

HARD-TO-FIND, UNIQUE PRODUCTS for HOBBYISTS, GADGETEERS and STUDENTS

from America's Largest Mail-Order Market Place of Unusual Values in Telescopes, Binoculars, Magnifiers, Solar, Microscopes, Science Kits, Lab Equipment, Toys, Military Surplus, Lasers, Photo and Weather Instruments.

GRAB BAG OF SCIENCE FUN

...W! Explorabook™... A Kids' Science Museum in A Book.

A 'hands-on' interactive science discovery book/kit features over 100 pages of activities bound right into this beautifully printed spiral book. Mix up agar for a bacteria study, read a cartoon through a fresnel lens, study optics with a plastic lens and a foil mirror, and design your own optical illusion with a moiré spinner. Take the ouch out of physics! Ages 6 and up.

"The best science fun book for young scientists" **ES Staff**

"The best present a child could receive." **Robert Edmund.**

SM4766 $17.95

Perform Experiments With Equilateral Prisms Discovered By Sir Isaac Newton.

Prism discovery optics have three equal 60° angles, ideal for classroom demonstrations. Turn sunshine into rainbows, bend light, even make a periscope. You can perform Newton's basic dispersion of white light into the spectrum experiments. All made of optical glass. Face is 25mm.

50mm, SM31,801 $5.35 100mm, SM31,798 $6.85
75mm,SM31,797 $5.75 150mm, SM31,799 $9.25

Build Your Own 2000° Solar Furnace With This Fresnel Lens And Harness The Sun's Rays!

You'll be able to use this precision lens as a solar cooker for heating food, as a kiln for pottery – and even to melt metal or for other solar experiments. Lens has a 8⅛" f.l., 50 lines per inch, measures 10½ x 10½", ⅛" thick. Unmounted lens comes with instructions on how to build the 360° stand and frame shown.

SM70,533 $29.25

Go Fishing With This Mighty Magnet.

Lift up to 200 lbs. Fun to use around docks and bridges. A 'must' for a boat. It helps retrieve metal objects that fall overboard. You'll be amazed at what you pull up. Wt. 2 lbs., measures 4x3⅜x3¼". Made with a Poly-Vinyl Chloride coating to resist corrosion and chipping.

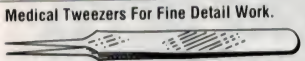
SM71,135 $33.95

Build Your Own Hot Air Balloon That Will Actually Rise 200 Feet.

...en inflated, this 12 foot colorful balloon will ...above the houses and trees and you'll feel ...excited as the Wright brothers at Kitty Hawk. ...t will even lift a "payload" of ½ pound. Kit includes 10 pre-cut gores, 12 gauge wire for ring and core.

12 Ft. Kit. SM31,333 $19.95

Medical Tweezers For Fine Detail Work.



Superior precision, surgical quality pair of tweezers are hand crafted out of 100% stainless steel. Ideal for removing splinters, ingrown hairs; will tweeze the finest hair, 4 ⅜"x⅝"x⅛". Opens to ⅜".

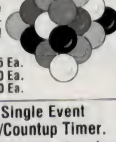
SM31,345 $10.50

The Vortx™, More Than A Money Bank!

Performs spinning tricks and high maneuvers. Drop a coin onto the launching pad, spin the Vortx unit in a circular motion. This creates an immense amount of speed, causing the coin to spin around and around until it finally drops to the bottom storage area. ***"The longest continuous rolling so far is 33 hours, 16 minutes."*** Challenge your skills, spin the coin back up the tunnel or spin it upside down, plus more. Made of tough polypropylene. Instructions included.

SM37,832 $18.50

Fun And Intriguing! You'll Play For Hours With These Colorful Magnetic Magic Marbles.



Build a mountain or odd geometric patterns with these fascinating, high impact plastic marbles. Each marble has both a negative and positive pole. A challenge to your imagination. Fun for youngsters, adults too! 20 marbles per package.

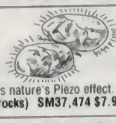
SM34,968 (Package of 20) @ $3.95 Ea.
(5 Packages or more) @ $3.70 Ea.
(10 Packages or more) @ $3.20 Ea.

Easy To Read, Easy To Set Single Event Countdown/Countup Timer.

LCD display timer counts down from 99 minutes, 99 seconds and counts up to 60 minutes by the second. Loud 1 minute duration alarm for countdown. Full digit keypad for easy setting. Powered by single 1.5V button battery, included. Timer has 3-way mount: snap-clip, magnet and table stand.

SM37,674 $23.95

Flash Rocks.



Strike them together and see amazing flashes inside the rocks! The source of light is a miniature ***"lighting flash"*** that occurs in the quartz material within the rocks. It's nature's Piezo effect.

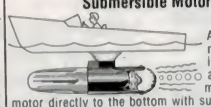
Pack of 3 bags (6 rocks) SM37,474 $7.95

Watch A Society Of Ants Dig Tunnels, Build Bridges And Move Mountains Before Your Eyes!

Ants are the worlds finest engineers... and seeing them plan and construct their intricate highways and subways is fascinating. Through the large plastic case of the cage (10x15") of this giant ant farm, you'll see the ant soldiers guarding the roads, the laborers carrying their load and the supply corps storing away food for the whole colony. When you return the enclosed certificate you'll receive by return mail (in about two weeks) a large quantity of harvester ants. Complete with white sand. Ants cannot be shipped via mail in TN and HI.

SM70,295 $19.95

Add Power To Your Model Boat With A Submersible Motor And Propeller



SM39,289 $6.00

Add power to boat models or any floating toy by simply attaching this submersible Mabuchi motor directly to the bottom with suction cup or glue. Powered by one "AA" battery (not incl.). Internal motor turns a small 2 blade propeller, adj. rudder. Measures 4 ¾" x 1".

Can You Tell Which Ball Is A Happy Bouncer, And Which Ball Is Not?

Two seemingly identical black spheres with marked differences in their physical properties. They have the same density, mass, color and appearance; yet when dropped to the floor one jumps wildly, the other is motionless. Marvelous thought provoker for discrepant event science. Fact sheet on physical and chemical properties plus experiments for classroom use incl.

SM39,129 $3.25/Pair; 10 Pairs or more $2.75

Become A Window Box Gardener And Watch The Underground Development Of Seeds And Roots.

A fascinating garden laboratory lets you view the underground development of seeds and roots through a clear window. Watch carrots radishes and onions take form. Our Root-Vue kit includes grow box with acrylic window, light shield, soil mix, seeds, identification labels and simple to follow instructions.

SM52,059 $24.95

Great AM Radio Reception With Select-A-Tenna. Listen To Station WOR N.Y. When In Boston.

This new antenna will bring in those weak, distant AM radio signals loud and clear. You'll now get excellent radio reception on all AM stations. Select-A-Tenna turns your AM radio into a powerful receiver. Used in Alaska to pull in stations from continental US. Employs mutually inductive coupling. Mini-jack and plug 10³/₃₂" in dia.

SM72,147 $59.95

Add Spectacular Color To Your Home With A Rainbow Light Display.

Our equilateral prism mounted in an attractive high tech positioning base catches the sunlight from your windowsill and projects the ever-changing rainbow patterns over your walls, ceiling and floor. It's almost like being inside a multifaceted diamond. Glass equilateral prism is 2" (50mm) long with 1" (25mm) faces. Black plastic mount is 3"x1⅜"x1⅜".

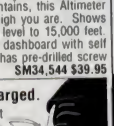
SM38,400 $7.50

This Clever Gadget Will Tell You How High You Are.

Whether you're driving cross country or hiking in the mountains, this Altimeter will tell you how high you are. Shows elevation from sea level to 15,000 feet. Can be mounted to dashboard with self sticking tape (incl.) or has pre-drilled screw holes. Built-in barometer included.

SM34,544 $39.95

Every Detail Of Your Eye Enlarged.



Check contact lenses and inspect your own eye with our unique close-up eye inspection mirror. Our precision radius mirror with front surface coating allows you to inspect your own eye by simply holding the mirror approximately 2 inches in front of your eye. Ideal for contact lens wearers or to inspect for irritant allen particles. Mirror is 2 inches in diameter with front surface aluminized coating.

SM39,152 $9.95

The Cloud Chamber, An Introduction To The Science Of Particle Physics.

A unique science classroom experiment that demonstrates how clouds are formed. Cloud chamber includes a needle tipped with an alpha particle source, an absorbent base material and a styrofoam insulating block. When saturated with alcohol and cooled with dry ice, a cloud of alcohol vapor is created in the chamber. If a bright light source is introduced, the curved tracks of alpha particles appear as condensation of droplets.

SM39,830 $19.95

Our Lowest Price Compact Laser Pointer... It's Lightweight, Measures Less Than 5".

NEW!

Ideal for lecturers, educators, instructors, other professionals. It projects a brilliant red laser dot to focus attention to slide presentations, charts, business and sales meetings at distances up to 300 feet. This compact pen style class IIIa laser pointer is crafted of the finest materials and built to the highest industrial standards. 1½ hours continuous battery life, uses 2 "AAA" batteries incl. weighs less than 2 oz. Rated output: 3mW at 670mm. Carries 3 yr. manufacturers limited warranty.

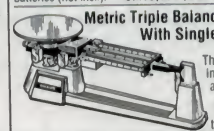
SM52,117 Price Breakthrough! ONLY $89

Illuminating 30X Magnifier-Microscope For Examining Stamps, Coins, etc.

Our new design improves this popular model. Carry it with you everywhere, measures only 5 ¼" x 1⅝" x ¾". Ideal for critical inspections. Has a built-in light source and optics to let you examine objects 30 times actual size. Features a center focus wheel for precise one-hand operation. Ideal for industrial inspections and hobby applications. Uses 2 "AA" batteries (not incl.).

SM35,001 $9.50

Metric Triple Balance Ohaus Scale With Single Pan Balance.

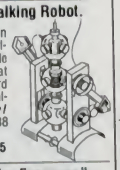


The classic weighing instrument provides accurate weights year after year. Rugged construction, weigh anything – liquids, solids or live animals. Three tiered, notched beams (100-550, 10-100, 0-10 grams) have center readings, sliding poises. 610 gram capacity. Stainless 6" platform 18x6x6".

SM71,695 $93. Acc. Wt. Set, expands scale to 2, 610 cap. incl. 1-500 and 2-1000 gram wts.

SM41,766 $26.

Build Your Own Motorized Walking Robot.



A Capsela discovery toy can be an exciting introduction to robot technology and engineering. You'll be able to build a slow-motion robot and, at your command, watch it move forward or backward in perfect calibrated balance. ***It almost becomes alive!*** Contains complete instructions and 38 interlocking parts.

SAVE! REG. $27

SM39,858 SPECIAL $24.95

"700 Science Experiments For Everyone"– An Exciting Book For Science Fair Projects.

New, up-to-date edition of the best known science experiment book in the world. Compiled by science instructors under the auspices of UNESCO in Paris. 251 pages, featuring optical projection, electricity, chemistry, astronomy, magnetism, geology physiology and more. Describes experiments with easy-to-follow instructions, diagrams.

SM9301 $13.95

Radiometer...A Space Age Sphere.

It's fascinating to watch the delicate vanes within this 5" precision-made sphere spin faster and faster illustrating the basic principles of solar heating. When light strikes the vanes it transfers heat and the vanes begin to move. Works from direct sunlight or artificial light. An attractive conversation piece

SM60,082 $6.95

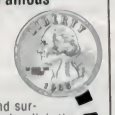
Close Inspection Is A Snap With The Edmund 25X Pocket Microscope ONLY $10.95 with purchase of any item from this ad

SM36,843 *Reg. $15.00*

Carry this pocket microscope with you – it's only 5" long. Brushed aluminum finish. Precision ground lens system gives distortion free detail inspection. Clear acrylic base gives sharp view.

Offer Limit: Only 1 per order

Edmund's Famous Jumping Quarters Leap 3 Feet Into The Air!



Full of fun and surprises. Simply click the jumping disc between your fingers, rub for a second, lay it on any smooth surface... ***and POP!*** It leaps into the air, 3 feet high. Friends won't be able to resist tinkering with them. ***How does it work?*** The nickel and stainless steel discs work on the principle of thermodynamics. Heat (rubbing the discs) makes metal expand, a cool surface makes it contract.

12 Jumping Quarters SM42,099 $4.25

Make Rocketry Your Next Science Project.

Junior astronauts and scientists... now you can actually make a rocket capable of flying up to 100 feet high. All you need is this kit, an empty plastic bottle and a bicycle pump. Powered only by air and ordinary water, it will develop approx. 25 PSI with a theoretical thrust of 3.9 lbs. Can be flown hundreds of times. Complete instructions included.

SM39,978 $19.95

Make Your Own Wild Tornado.

Our Tornado Tube assembly allows you to demonstrate the wild vortex phenomenon of a natural tornado. All you need are two 1 or 2 liter plastic soda bottles and ordinary tap water. Instructions and explanation of scientific principles included.

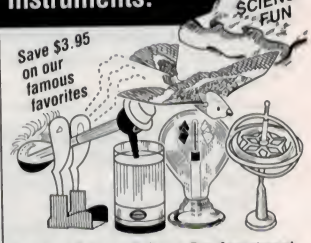
Pkg. of 2 tubes SM37,592 $3.95

Our Amazing Happy Bird Never Stops Drinking!

Fascinating to watch. Simply duck the bird's beak into a glass of water to begin happy birds bobbing motion. Then the bird takes over, continuously dipping into the water for a drink.

SM60,778 $3.95

Save $3.95 on our famous favorites

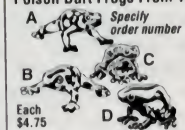


Our Most Popular Science Fun Assortment.

Classic science demonstration toys have amazed and intrigued young minds for many generations. You'll have fun and learn scientific demonstrations with these favorites:

- **Perpetual pointing bird** ***A $25.80 Value***
- **Whirling gyroscope** **SM37,471**
- **Sun-powered radiometer** **SPECIAL PRICE $21.95**
- **Amazing flying bird**

Poison Dart Frogs From The Rainforest.



Specify order number

Each $4.75

Designed in cooperation with the National Aquarium in Baltimore. Each colorfully hand-painted frog is 2½" long. The toxic poison found in the skin of these frogs has been used for centuries by Indians who use it to coat the tips of their blowgun darts or kill their prey and by medical research to benefit mankind.

A) Azureus (Blue) SM39,682
B) Auratus (Green) SM39,684
C) Histrionicus (Orange) SM39,683
D) Dendrobates Tinctorius (Blue & Yellow) SM39,963

before hunting to stun

Have You Ever Seen The Inside Of Your Eye?

Eyescope is an optical device for looking at the inside of your eye. It's a specially designed diffuser incorporating a parabolic mirror and lens light. Safe and easy to use. A 52 page booklet included, describes the various features inside the normal eye, how the iris works, kinds of floaters and fixed objects, how to inspect contacts.

SM33,538 $29.95

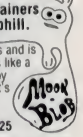
Deal An Optical Illusion Next Time You Play Poker, Blackjack or Gin Rummy.

Visual illusion cards are a great conversation piece for your card games. Contains 52 different visual illusions and instructions. Examples: Illusions in color, color reversal, ambiguous figures, size and figure distortion. Card Size: 3½"Lx2½"W. Two card decks available.

Deck A **Deck B**

Deck A: Can You Believe Your Eyes SM39,635 $7.50
Deck B: More Illusions & Visual Oddities SM39,636 $7.50

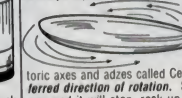
Moon-Blob, It Crawls Out Of Containers And Looks Alive As It Creeps Uphill.



Moon-Blob has unbelievable properties and is fun to play with...it acts alive and looks like a living protoplasm as it defies gravity by crawling up and out of its container. It's dehydrated plastic - just add water to activate it. Completely harmless.

SM38,440 2 Packages, $7.25

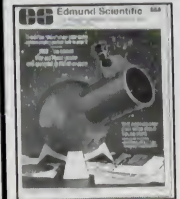
Why Does This Amazing Space Pet or Celt Always Spin In A Counter Clockwise Direction?



Originally called "Celts" because their curious properties were first discovered by archeologists studying prehistoric axes and adzes called Celts. ***These rocks had a preferred direction of rotation.*** Spin the space pet ***the other way*** and it will stop, rock up and down on the long axis, and then reverse its spin. Hint: the round edge is an ellipsoid, with its axis aligned at an angle of about 5° to 10° from the main axis of the stone. Angular momentum is conserved, but it doesn't look it. Made of injection molded acrylic. Size: 3⅛" x ⅝" x ⅛".

Pkg. of 3 SM38,912 $5.95

FREE 112 PAGE CATALOG



Featured on this page are only a few of the many imaginative products that appear in our new catalog.

Send for your copy today

Thousands of exclusive, unique and exciting values. Something educational, fascinating and useful for every hobbyist, gadgeteer, student and educator.

Edmund Scientific Co.
Dept. 13D5, C922 Edscorp Bldg.
Barrington, NJ 08007

METHOD OF PAYMENT:

☐ Check enclosed ☐ VISA
☐ MasterCard ☐ Diners Club
☐ American Express ☐ Carte Blanche
☐ Discover ☐ Optima

Exp. Date

Card Number

Bank Number (MasterCard Only)

Signature

STOCK NO.	QTY.	PRICE

Total Price

In NJ Add 6% Sales Tax

Add $2.50 for postage & handling

TOTAL ENCLOSED

☐ RUSH FREE 112 PAGE FULL COLOR CTALOG

Name

Address

City State Zip

Serving Science Hobbyists Since 1942

No Risk Guarantee! If you are not completely satisfied with your purchase, return the merchandise in its original package and we will cheerfully refund your money in full. **We back our products!** Our 45 day unconditional guarantee means you take no risk on any product you buy from us.

For Phone Orders, Call 1-609-547-8880
for friendly special treatment

Use Visa, MasterCard, Diners Club, Am. Exp., Discover, Carte Blanche or Optima. Call anytime, 24 hours a day.
MOST ORDERS SHIPPED WITHIN 48 HOURS

Edmund Scientific Co.
Dept. 13D5, C922 Edscorp Bldg., Barrington, NJ 08007

Books

Books is an editorial service for readers' information. To order any book listed or any U.S. book in print, please remit retail price, plus $2.00 postage and handling charge for each book, to **Science News Books,** 1719 N St., N.W., Washington, DC 20036. To place Visa or MasterCard orders, call 1-800-544-4565. All books sent postpaid. Domestic orders only. Please allow 4-6 weeks for delivery.

Agenda 21: The Earth Summit Strategy to Save Our Planet — Daniel Sitarz, ed. From the June 1992 Earth Summit in Rio de Janeiro came a 900-page treatise, called Agenda 21, outlining a course of action in response to the world's most urgent environmental, health, and social problems. This book is an abridged version of Agenda 21, rewritten in easily comprehensible language. Each chapter focuses on a specific issue, describing the proposals presented in Agenda 21. EarthPress, 1993, 321 p., hardcover, $24.95.

The Cartoon Guide to (Non)Communication: The Use and Misuse of Information in the Modern World — Larry Gonick. From the author of *The Cartoon Guide to Physics* and *The Cartoon Guide to Genetics* comes a humorous look at the evolution of writing, language, and communication through the ages and the confusion that ensues as people and cultures change. Learn the importance of visual perceptions and manipulation techniques. HarperPerennial, 1993, 186 p., b&w illus., paperback, $13.00.

To order by Visa or MasterCard, call 1-800-544-4565
In D.C. Area: 202-331-9653

Dictionary of Astronomy — Jacqueline Mitton. This invaluable reference for anyone studying or writing about astronomy includes tables of the stars, constellations, and characteristics of the major planets and their orbits, as well as spellings and explicit definitions for astronomical terms ranging from apogee to the ZZ Ceti star. Penguin Bks., 1993, 431 p., illus., paperback, $12.00.

Exploding the Gene Myth: How Genetic Information Is Produced and Manipulated by Scientists, Physicians, Employers, Insurance Companies, Educators, and Law Enforcers — Ruth Hubbard and Elijah Wald. A biologist and a writer contend that genetic explanations for human traits are often exaggerated or unfounded and that the current explosion of genetic information threatens to infringe upon individual privacy and civil liberties. This is a readable and compelling look at the possibilities, prophecies, and propaganda of genetic research, with special emphasis on the Human Genome Project. Includes a glossary. Beacon Pr, 1993, 206 p., hardcover, $24.00.

The Life of Isaac Newton — Richard S. Westfall. This easy-to-read, condensed version of Westfall's original biography of Newton, *Never at Rest*, chronicles in narrative form the life and work of one of science's greatest geniuses. Westfall, who studied an extensive collection of published and unpublished personal writings, delves into many of Newton's controversial philosophies, his scientific achievements, and his somewhat peculiar personality. Cambridge U Pr., 1993, 328 p., illus., hardcover, $24.95.

Life Under a Cloud: American Anxiety About the Atom — Allan M. Winkler. This well-documented overview chronicles the events following the advent of nuclear weapons and examines how atomic weapons and atomic power have affected our way of life over the last 50 years. Winkler contends that people react only in the face of disaster. With the the demise of the Soviet Union, he says, we are once again putting atomic concerns out of mind — yet many issues are left to consider, such as the fate of Soviet nuclear arms, the disposal of nuclear waste, and the continued buildup of nuclear arsenals in some countries. Oxford U Pr, 1993, 282 p., hardcover, $27.50.

Living With Cats — Gale B. Nemec. The host of the PBS show "Living With Animals" brings together her experiences in this complete sourcebook on cat care. Highlights include selecting and naming a cat, understanding feline ailments, cat-proofing the home, and dealing with the loss of a pet. Learn why 42 percent of pet-owning U.S. households have two or more cats. Quill, 1993, 224 p., b&w illus., paperback, $8.00.

Why We Eat What We Eat: How Columbus Changed the Way the World Eats — Raymond Sokolov. A lively and informative history of the culinary exchange that followed the opening of trade routes between Europe and the Americas. This book will overturn your ideas of "traditional" cuisines: Before 1492, Italians had no tomatoes for sauce and Mexicans had no cheese for quesadillas. Originally published in hardcover in 1991. Touchstone Bks, 1993, 254 p., paperback, $11.00.

Anthropology

Bruce Bower reports from Toronto at the annual meeting of the American Association of Physical Anthropologists

Jawing with an ancient ape

A fossil jaw found on Maboko Island in western Kenya suggests that an ape-like creature that lived between 14 million and 16 million years ago was a close relative of the as-yet-unidentified common ancestor of modern apes and humans, according to the specimen's discoverers.

Monte L. McCrossin of the University of California, Berkeley, and Brenda R. Benefit of Southern Illinois University in Carbondale unearthed the lower jaw in 1988. Based on an analysis of the bone and the eight teeth it retains, they assign the fossil to the species *Kenyapithecus africanus,* previously known from fragmentary remains.

The presence of deciduous teeth, which fall out during dental development, indicates that the jaw belonged to a juvenile, perhaps 6 or 7 years old, McCrossin says.

Tooth shape and arrangement in the fossil resembles that of modern apes more than other groups of ancient apes from around the same time period, McCrossin asserts.

K. africanus displays a thick jaw that slants forward slightly, he points out. Large incisors at the front of the mouth jut out and apparently helped to crack open hard fruit and nuts before these foods were crushed and chewed by thickly enameled cheek teeth, according to McCrossin.

Excavations at Maboko last year uncovered several lower-body bones that probably belonged to a single *K. africanus,* Benefit says. Two fossils—the top of an upper-arm bone and the top of an upper-leg bone — fit neatly on the shafts of a *Kenyapithecus* arm and leg bone, respectively, collected at the same site in 1933 and now housed in Kenya, she adds.

These reunited fossils will greatly increase understanding of how *K. africanus* moved about, Benefit notes.

However, anthropologists have not established the evolutionary connections among *Kenyapithecus* and the more than 20 other ape-like genera that lived between 25 million and 5 million years ago, says Carol V. Ward of the University of Missouri in Columbia. Some of these groups probably developed similar skeletal traits in the absence of any ancestral links to each other, Ward holds, a process that throws a monkey wrench into current fossil comparisons.

An ancestor's unusual shape

In 1924, anthropologists working at the Sudanese site of Singa found the upper portion of a skull embedded in rock along the Nile River. Some investigators consider the Singa skull an example of an anatomically modern human ancestral to Khoisan hunter-gatherers still living in Africa. Others argue that the specimen represents a more primitive, or archaic, form of modern humans that lived around 100,000 years ago.

New evidence supports the latter view, reports Christopher B. Stringer of the Natural History Museum in London, England. Measurements of the Singa skull's shape more closely match those from archaic *Homo sapiens* fossils than those from anatomically modern humans, Stringer asserts. Preliminary efforts to date two animal teeth found in the same sediment as the Singa skull place them between 97,000 and 160,000 years old.

Some type of disease may have altered the shape of the Singa skull and thus misled earlier investigators, Stringer contends. The brain case appears low for an archaic human and shows significant widening toward the middle. Computed tomography (CT) scans reveal thickened bony tissue in central skull bones that may have contributed to the specimen's shape, he maintains.

The right side of the fossil sports a small hole where the bones of the middle ear normally lie, Stringer notes. He considers this an inborn defect.

"This fossil has unusual features, and we need to understand its pathologies much better," Stringer says.

Physics

Ivars Peterson reports from Washington, D.C., at an American Physical Society meeting

Physics in storage rings . . .

Strip all but one of the 92 electrons from a uranium atom and the result is a highly charged positive ion. Add an electron to a calcium atom and the result is a negative ion that barely holds on to its extra electron. Neither type of charged particle lasts long enough to be studied in typical laboratory settings.

Researchers can now investigate the characteristics of these particles by injecting streams of them into new, specially designed storage rings. Confined and focused by magnetic fields, such beams circulate through a sequence of vacuum chambers. Continually speeding around this atomic racetrack, individual ions remain far enough from their neighbors and sufficiently isolated to survive for long periods.

. . . with stripped atoms

At the Institute for Heavy Ion Research (GSI) in Darmstadt, Germany, researchers are starting to use a new storage ring to look at the behavior of highly charged ions. With only one or two electrons, the positively charged nuclei of these ions exert such a strong force on the few electrons present that subtle quantum and relativistic effects — barely detectable in a hydrogen or helium atom — become greatly amplified. By detecting X-rays emitted by these tightly bound electrons as they jump from one orbit to another, researchers can generate data to help test theories of how electrons interact.

"One-electron atoms are the simplest systems we can calculate, and from the experiments, we get a very stringent test of the theory," says GSI's Paul H. Mokler.

Researchers at GSI have also observed for the first time an extremely unusual type of radioactive decay in which the electron (beta particle) produced by the decay of a "parent" nucleus stays bound to the newly created "daughter" nucleus instead of speeding off. The physicists started with highly charged dysprosium ions. Although neutral dysprosium-163 is stable, the naked nucleus — the atom stripped of all 66 of its electrons—is unstable and decays by emitting a beta particle to create a holmium-163 nucleus, which captures the beta particle and hangs on to it as an orbiting electron. Extremely rare if not impossible in neutral atoms, "bound-state beta decay" may play an important role inside stellar plasmas during the synthesis of elements via nuclear fusion reactions.

. . . with negative ions

Torkild Andersen and his collaborators are using the new storage ring ASTRID at Aarhus University in Denmark to investigate the weak interactions of electrons loosely bound to atoms and simple molecules. These fragile negative ions hold together long enough in the storage ring to allow researchers, for the first time, to measure accurately how long the particles retain their charges. The lifetimes range from 10 microseconds to 100 milliseconds. The examples studied so far include singly charged, negative ions of helium, beryllium, and calcium and a molecular ion consisting of two helium atoms bound together with an extra electron (He_2^-).

"We have been able to show that the lifetimes are considerably shorter than expected from theory, and the theory is now going to be revised," Andersen says.

Some negative ions are so delicate that the heat (blackbody radiation) of the apparatus itself at room temperature is sufficient to knock out the extra electron. "This was a surprise because . . . you don't expect this energetically weak blackbody radiation to remove electrons," Andersen says. But "if you go to a very weakly bound system, it will be the controlling factor." For example, the binding energy of the extra electron in a negatively charged calcium ion is sufficiently low that the ion's measured lifetime of 490 microseconds is determined almost entirely by environmental blackbody radiation.